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ABSTRACT

The possible objectives of information science education can be categorized into three general types: professional training intended to equip people to operate existing communication institutions; training of information technologists who will be the inventors or engineers expected to develop and test new information systems; and training of scientists whose goal is a deeper understanding of information processes in general. This paper describes objectives and methods for reaching these objectives within each category from the point of view of librarians, and argues for training programs at each category which combine elements and emphases from the other categories. Stanford's information systems Ph.D. program is briefly described. (Author/SH)

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INFORMATION SCIENCE EDUCATION

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Information Science Education

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We can categorize the possible objectives of information science education into three general types. The first, and most prevalent, is 'professional' training intended to equip people to operate existing communication institutions. Given the sponsorship of the present symposium I will use libraries as examples throughout, although I think the argument generalizes to other communication institutions also. The second objective is to train information technologists who will be the inventors or 'engineers' expected to develop and test new information systems. My definition of a technologist is a broad one that includes behavioral and policy considerations. The third objective is to train scientists whose goal is a deeper understanding of information processes in general.

Professional Training

Technology Utilization

We can subdivide professional training into three general aspects, although one aspect dominates and the other two tend to be neglected. The dominant aspect of professional training for which information science is relevant is the utilization of technology. That may seem surprising to a librarian who works with books and card catalogs and typewriters or to a

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newspaper reporter who works with a pencil and paper, telephones and a typewriter. But the technology of writing and printing is as much a technology of information processing as photography (micro or otherwise), electronic transmission, or computer processing. Librarians share with journalists, photographers, film-makers, broadcasters and computer programmers the need to be able to effectively operate or manipulate their chosen technology or medium of communication.

Management Training

The second necessary aspect of professional information science training is management or organizational skill training. Communication institutions, whether newspapers, libraries, broadcasting companies or telephone companies, share with other institutions the need for people who can operate effectively within the existing institutional framework. Although the skills needed are in large measure communication and information processing skills, this need is not restricted to communication institutions. Graduate schools of business devote more explicit attention to training in the organizational and management skills needed to operate any institution.

Use of Feedback

The third and most neglected aspect of professional information science training concerns the relationship of the communication institution to the rest of society. In the case of business institutions, this task is much simpler than for libraries. Businesses have a well defined medium of communication for relating to the rest of the society -- money. Money provides the differentiated feedback to tell the institution which of its products and services are appreciated and the profitability test provides

an accepted measure of success. Market research is one way of obtaining information from the potential clients of the institution that can help it perform more effectively. Public institutions such as libraries find it much more difficult to determine user needs and interests, to evaluate the effectiveness of their operations, and to provide the systematic information feedback that allows them to be rapidly responsive to changes in needs and interests of their clients. Since the financial resources of libraries come from different sources than those served (or come indirectly) there is the additional problem of obtaining resources to operate. Sometimes successful service can be self-defeating in that it generates further demands for service that cannot be met because of budget constraints. These problems are crucial to the long-run survival of public information institutions. They deserve more attention in professional training.

Training Tomorrow's Professionals for Yesterday's Institutions

This characterization of professional training as training to operate existing communication institutions, although useful for some purposes, is a dangerous oversimplification. If the communication media and institutions were likely to remain stable throughout the careers of those being professionally trained there would be few problems. But during a time of rapid technological change in communication media that will certainly leave its mark in the form of changes in communications institutions, there is a danger that tomorrow's professionals may be trained for yesterday's institutions. The institutions themselves, whether libraries or newspapers or whatever, are likely to demand personnel trained to handle the immediate short-run problems. The questions that education institutions must answer is whether they also wish to take the short-run view, or whether they have a larger responsibility to consider the long-run

problems. It is a matter of whether the education institutions choose to lead or to follow the professional institutions they serve. If they are to lead, then it is imperative that professional training also include elements of our two remaining categories of information science education -- technology development and scientific understanding.

Technology Development

Change Technology or Change Function?

Communication technology is undergoing considerable change and is likely to continue to do so for at least the next 20 years. There will be major changes in information storage technology (e.g., ultrafiche, trillion bit laser memories, holographic memories, etc.), in transmission technology (e.g., cable television, communication satellites, laser transmission, etc.) and in access and processing technology (primarily computer systems). As new technological potentials are developed, made more economical or more widely diffused through the society, then shifts in usage patterns are bound to develop and institutions that have grown up around earlier technologies will be forced to adapt. Existing institutions will be forced to change technologies (if they are to continue to perform the same functions effectively) or to change function (if they insist on keeping the same technology).

I am a strong supporter of libraries in their functional role of providing all people with easy access to information and education about whatever they want whenever they want. The library has long been a cornerstone in our democratic system of government, which requires an informed

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electorate to operate effectively. This historic role of being the receiver's agent in a communication system that has in the past been largely dominated by the senders of messages, is becoming increasingly important as the society itself becomes more complex and as individual citizens become more involved in the decision-making processes of the society. Therefore, I am a strong advocate of libraries developing and adopting whatever technologies can best help them to serve that function. The alternative would be for libraries to maintain only their traditional technologies and permit new institutions to grow up around the new technologies, possibly usurping the library's traditional function. The implication for educational institutions is clear: Train people who can develop and adapt new technology and new techniques to make it easier to provide the kind of information access capability our society requires.

New Technologies

There are two dominate technologies involved in current and future changes in information access capability. One is computer technology and the other is a cluster of video technologies, including videotape, video cassettes, cable television, photocopying devices, microfiche, etc. It should not be necessary for the information technologist to become a hardware engineer capable of developing new physical devices, although he should be able to understand the hardware well enough to utilize it effectively. He should also be able to write specifications for needed hardware in a form understandable by the appropriate hardware people. One example of this would be specification of characteristics necessary in a computer display terminal for bibliographic data in a library application.

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Another would be specification of performance characteristics needed in a random access microfiche system. He should also be familiar with the major trends in technology to be able to judge which aspects are likely to remain stable and where the significant technical developments and cost reductions are likely to appear in the following five to ten years.

He should become a highly competent user of the technology so that he has a first-hand knowledge of both potentials and limitations and can select hardware knowledgeably. In the case of computer technology, he should become more than an applications programmer capable of writing programs in some standard programming language whether Basic, Cobol, Fortran or Assembler. He should become knowledgeable about the systems programming skills needed to implement a new programming language or system which non-programmer users can use effectively to perform their information selection and processing tasks.

Behavioral Research

The goal of developing effective new information systems requires two additional areas of knowledge besides the obviously technical skills required for development of a computer or video information system. A second area of knowledge concerns user needs and user behavior. Technology systems developed in isolation from the needs and information-seeking styles of specific audiences may work well in some technical sense, but are unlikely to be satisfactory for real users. One danger is that the system may be designed for an imagined rather than a real need. Another is that the 'human factors' are not adequately taken into account to make it easy for non-technical users to comfortably utilize the system. What needs

to be developed is not a technology system but a man-machine symbiosis that allows real users to access relevant information on real problems. Designing a system for the general public to use is a much more difficult task than designing one that will be operated by paid employees or other captive audiences. Solid training is therefore required in behavioral science research techniques as well as technology systems development techniques.

Social Institutions and Public Policy

The third component needed for effective technology development is detailed understanding of existing communication institutions and public policies for communication. A potentially effective information system, even one that has adequately taken into account user needs and user characteristics, is likely to remain a laboratory curiosity if there is no reasonable strategy for existing institutions to make the transition from present to future technology or for new institutions to develop around the new technology. In the case of communication technology in this society, this requires an understanding of the regulatory process. The promise of electronic technology for remote access to library services may never be realized if Federal Communications Commission regulations and local cable television franchising practices do not take into account the possibility of libraries extending their information services directly to homes via the new communication technology. New technologies are never introduced into a social vacuum. The economic, political, and social consequences for existing institutions must be studied as carefully as the technology and the behavior of its users. The systems designer and developer who ignores the problem of transition strategies for social institutions, in this case libraries, has a certain recipe for failure.

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All three of these components of effective information systems development -- technology, human behavior, and social institutions -- will require the acquisition of new knowledge as well as application of old knowledge. The problem is a mission-oriented one of accomplishing social goals, rather than a pure knowledge problem, but new knowledge is essential to satisfactorily accomplish the social goals of improved information service. Therefore, a strong component of information science, as a basic science, should be included in curricula planned for information technologists.

Basic Information Science

One reasonable goal for information science education, and one which can attain the greatest prestige within existing academic value systems, is that of training scientists. The goal can be expressed as deeper understanding, development of abstract principles, knowledge, truth, or some near synonym of these.

Fundamental Nature of Information

The nature of information and information processes may be the fundamental focus of science for the next century, just as science in the past two centuries has focussed on matter and energy. Information processes control the utilization of matter and energy. The fundamental relationship between information and energy has been suspected for at least the past 20 years since Claude Shannon's creation of the mathematical theory of information turned out to have equations identical to the entropy equations of the second law of thermodynamics. More recent developments in the

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understanding of the relationship between information and energy are discussed in the September, 1971 issue of Scientific American (Myron Tribus and Edward McIrvine, "Engergy and Information", Scientific American, 1971, vol. 224, number 3, pages 179-188).

The recent major advances in the biological sciences since Watson and Crick's discovery of the 'genetic code' can be largely attributed to the deeper understanding of how biological information is stored and transmitted from one generation to the next.

Although the analogies have yet to be formalized into an abstract theory of information, there are interesting similarities between machine information processing in computer systems, cognitive information processing in humans (biological systems), and human communication in social systems. All three aspects are involved in the development of information systems. Better understanding of the fundamental processes would be certain to lead to improved system design.

Toward a General Theory of Information

What is presently known as the mathematical theory of information, powerful though it is, is a very special case compared to what is needed in a general theory of information. Present theory is essentially a theory of efficient coding that measures the capacity of information channels and the efficiency of transmission in 'bits' (binary digits) of information under an assumption that there is a known set of possible messages that is perfectly shared between sender and receiver. In other words, the structure or context of the 'information' (as defined by a shared set of possible messages) must be identical at both ends of the information channel. This obviously does not apply to libraries or most human communication because

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the context of the message is different at the sending and receiving end. What is needed is a theory of information permitting rigorous formalization and measurement of changes in information structure, not just quantity of transmission within a given structure. If we can find a way to formalize the context or boundaries involved in processing an item of information (whether by man or machine) we might then be able to determine the extent to which information processing results in changes in the structure. (If we are thinking of a human being as an information processer we can think of this as changes in his cognitive map of his environment.) Given such a formalization we could measure similarities and differences in information structure between senders and receivers involved in a particular communication and determine whether their structures are moving closer together or farther apart.

Interdisciplinary Effort

The problems of information are so fundamental and cut across so many present disciplinary boundaries that it is nearly impossible to find an academic department within existing university structures in which to pursue a fundamental theory of information without being constrained by the assumptions of a particular discipline or profession. Cybernetics and general system theory come closest to the scope required but these are seldom found within a single department. A strong foundation in mathematics would be essential; there is some basis to suspect that the subfield of mathematics known as graph theory may provide a basis for formalizing information structures. Present information theory is the province of departments of electrical engineering. People wishing to explore the clues

in the relationship between information and energy will need a good grounding in physics. The fields of computer science, psychology, sociology and linguistics may provide necessary clues that permit a general theory of information to emerge. One can speculate that the present boundaries of academic disciplines and departments present a major impediment to the development of the needed basic theory of information. On the other hand, we will not know the appropriate way to draw academic boundaries until after the theory has been discovered; present intuitions may be quite on the wrong track. The closest analogy lies in the recent emergence of departments of molecular biology -- a trend which followed rather than preceded the discovery of the genetic code. One can argue that we need to have a theory to teach before we worry about finding an appropriate academic department to teach it in.

The crux of the present problem in education for a basic science of information is thus to provide a sufficiently flexible academic environment in which the holy grail of a general theory of information can be sought. An academic home needs to be provided for bright people who wish to study interdisciplinary programs involving such diverse topics as cognitive psychology, artificial intelligence, neurophysiology, molecular biology, and electrical circuit theory, all in the interests of developing a theory of information.

Stanford's Program

The information systems Ph.D. program which I direct in Stanford's Communication Department is focussed on technology development in the broad sense discussed earlier, including behavioral science, computer

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science (and use of technology generally) and analysis of social institutions. Much of our financial support comes from a training grant from the National Library of Medicine and so we have a particular focus on biomedical communication. Nevertheless, we feel that we are likely to be of most use to the National Library of Medicine if we approach the problem of developing improved information systems at a level of generality that would make the results apply to law libraries, technical information centers, public libraries or hospital systems for medical patient records. This would not be the case, of course, if we were engaged in the professional training of medical librarians. But we have only Ph.D. and postdoctoral programs. We do not offer an 'information science' program at the M.A. level, nor do we engage in any professional training in this area.

We do not teach a basic science of information as such, because we do not think that science exists yet. We do teach basic science in other areas, including behavioral science, which are needed to focus on information system problems. And we try to maintain the flexibility in our Ph.D. programs to provide encouragement for particularly well qualified students to tackle the fundamental information science problem if they wish.

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